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(54) Registered writing beam

(57) Before the manufacture of a mask or microcircuit by writing on workpiece 28 on table 10 using electron or light beam 20, the writing beam is accurately positioned with respect to the workpiece with the aid of second beam 32 which reads registration marks on the underside of the table (on the table itself, on a second workpiece, or on the underside of a single workpiece). The second beam may form as well as read the registration marks. The writing may be in a plurality of areas with intermittent movement of the table.

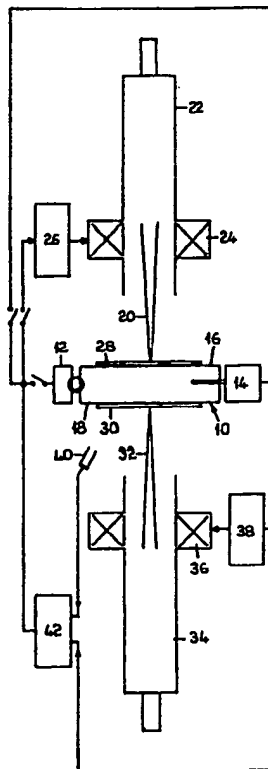


FIG. 1

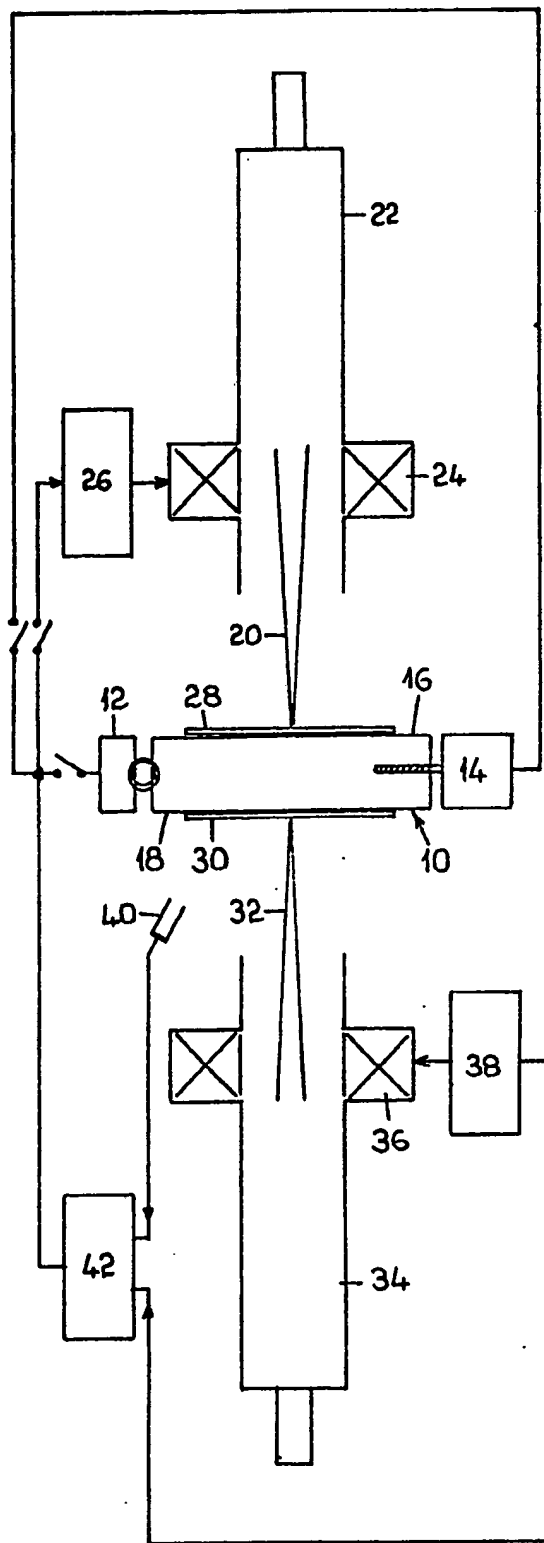


FIG. 1

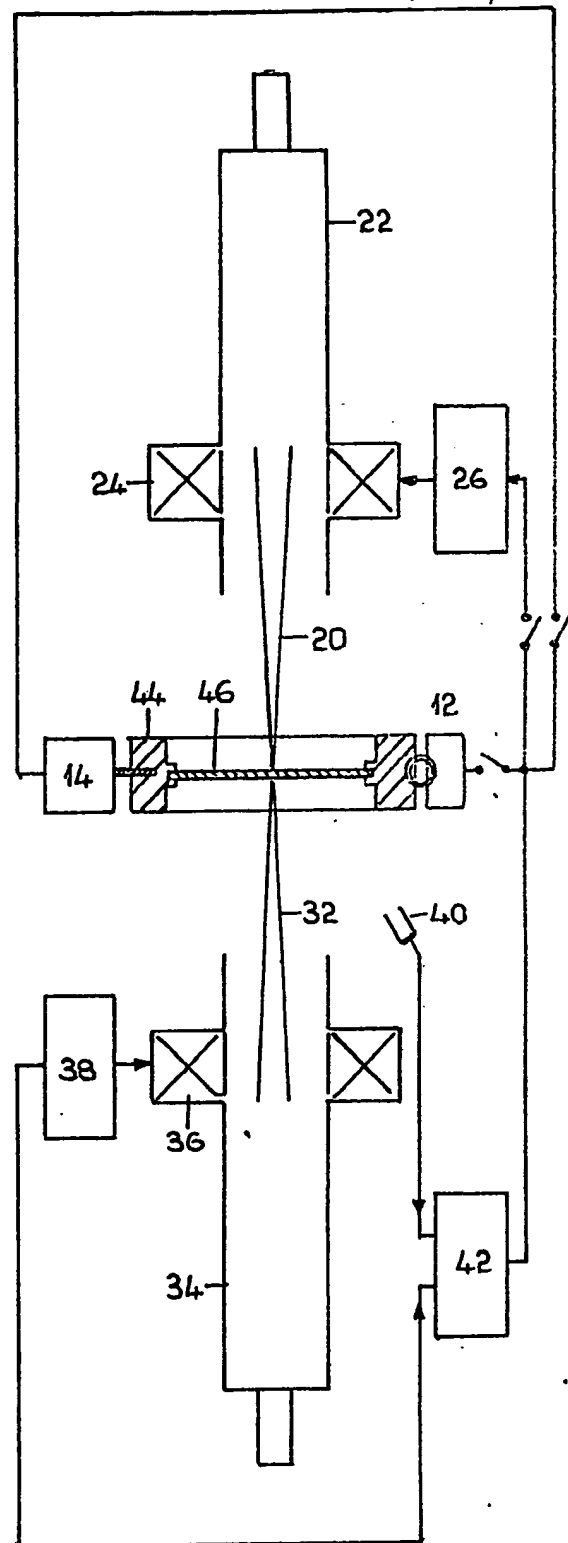


FIG. 2

SPECIFICATION

Inscribing apparatus and methods

5 *Field of invention*

This invention relates to apparatus and methods for inscribing accurately on workpieces. It has particular application in the manufacture of masks for use in the manufacture of microcircuits and devices and in the direct manufacture of microcircuits and devices on substrates or wafers.

Background to the invention

A workpiece in the context of this application may comprise a mask on which a circuit pattern is to be inscribed or may be a wafer or a substrate of the actual material on which the microcircuit or device is to be formed. Since the devices and microcircuits under consideration are typically very small in size, such workpieces must be positioned very accurately and must be capable of being moved extremely precisely.

To assist in this a workpiece or a worktable on which the workpiece is mounted has been provided with a set of registration marks which are used *inter alia* for alignment of the system. However the presence of registration marks on the surface of a workpiece on which a device or microcircuit is to be inscribed restricts the area on that surface which can be used for this purpose. To this end circuit designers are forced to design the circuits so as to avoid the places where the marks are to be positioned.

It is thus an object of the present invention to provide an apparatus for inscribing and a method of alignment of such apparatus which allow more freedom to the circuit designer and allow greater positional accuracy to be obtained in use.

The invention

According to the present invention inscribing apparatus comprises

- a work table having a working area,
- means for generating a first beam,
- means for directing the first beam towards one face of the working area, for inscribing the surface of a workpiece located in the working area,
- means for generating a second beam,
- means for directing the second beam also towards the working area but onto the opposite face thereof, and
- means for deriving positional information using the second beam.

Preferably means is also provided which is responsive to the positional information, for controlling the position of the worktable and/or the position of the first beam.

- The worktable may be provided with means for holding a second workpiece on the opposite face of the working area. Alternatively the table may be in the form of a frame so that both sides of single workpiece carried therein are exposed.

- In use registration marks are provided which are read by the second beam to provide the said positional information to provide *inter alia* for alignment of the system. The registration marks may be on the underside of the table or on the second workpiece or on the opposite surface of a single

workpiece.

The beams may comprise light beams or electron beams or ion beams. Typically both beams are capable of inscribing onto a workpiece surface. The second beam may be used for the initial writing of registration marks onto a workpiece surface and thereafter for reading those marks and providing the positional information signals.

- According to the present invention a method of positioning a first beam directed towards the one surface of a workpiece mounted on a worktable, comprises the steps of:-
- directing a second beam towards the opposite side of the worktable,
- deriving positional information using the second beam, and
- controlling the position of the point of impact of the first beam with the workpiece, using the positional information.

- The positional information may be obtained by using marks on the table or on a second workpiece carried on the said opposite side of the worktable or on the opposite surface of the one workpiece.

- The position of the point of impact may be controlled by adjusting the position of the table or the first beam or both.

The invention also lies in the method of inscribing a workpiece surface comprising the steps of:-

- placing the workpiece on a worktable accessible to two writing beams respectively directed to opposite sides of the table,
- using one of the beams to carry out the required inscribing operations on one surface of the workpiece and
- using the second beam to provide positional information to move the table and/or the first beam in accordance with registration marks read by the second beam and situated on either the table, or the surface of a second workpiece carried on the table, or the opposite surface of the first mentioned workpiece.

The invention will now be described by way of example with reference to the accompanying drawing.

110 *In the drawing*

Figure 1 is a diagrammatic view of apparatus embodying the invention and

Figure 2 is a diagrammatic view of another embodiment of the invention.

115 *Detailed description of drawing*

- Referring to *Figure 1*, a worktable 10 is provided with means 12 and 14 for moving the table in two orthogonal directions parallel to the plane of the table. The table 10 is accessible from its two opposite sides namely the top surface 16 and the opposing underside 18.

- Directed towards surface 16 is a writing or inscribing beam 20 from an electron column 22 forming a beam generating means. Deflection coils 24 are provided for moving the beam 20 and drive for the deflection coils is obtained from a control circuit 26.

A workpiece 28 is mounted on the upper surface 16.

- A second workpiece 30 is mounted on the underside 18 and is used as the registration surface.

A second beam 32 from a second electron column 34 constituting a beam generating means is directed towards the underside 18 of the table 10. The column 34 includes a set of deflection coils 36 control signals 5 for which are obtained from a further control circuit 38.

A sensor 40 associated with the second beam 32 generates electrical signal which in combination with position information from the control circuit 38 is processed by a signal processing stage 42 which produces positional error information signals which are fed back to the control circuit 26 and/or via switches to the drives 12 and 14 for moving the table 10 so as to allow for correction to be made both of the position of the beam 20 and the position of the table 10 in dependence on the positions of registration marks located by the beam 32 when operating in its reading mode.

The second beam 32 has two modes of operation. In the first mode it can be used to inscribe the registration surface with registration marks. In its second mode of operation it serves as a reading means as previously described.

Although sensor 40 has been shown separate from the electron column it is to be understood that any suitable method of generating the information during the reading mode may be used such as by deriving signals from the beam current variations during scanning.

Referring now to Figure 2, the same reference numerals have been used therein to denote similar components and the functions of these components where the same reference numeral has been used, are identical to the function of the corresponding components in the apparatus of Figure 1.

The primary difference between Figure 2 and Figure 1 is the worktable. In Figure 2, a frame 44 is used in place of the solid worktable 10 thus allowing a single wafer or substrate 46 to be supported with both its upper and lower surface exposed. The beam 20 is directed towards the upper surface of the workpiece 46 whilst the lower beam 32 is directed towards the lower surface. Since both surfaces are available, points of impact arise on both surfaces and by providing marks on the lower surface impinged on by the beam 32, so the system can operate in exactly the same way as has been described with reference to Figure 1. The advantage lies in the fact that the registration marks are provided on the underside of the actual workpiece so that any distortion or other changes occurring during manufacture of the microcircuit or device automatically produces a distortion in the positions of the registration marks on the underside of the workpiece 46 and accurate positioning of the upper surface of the workpiece for inscribing by the beam 20 during subsequent processing can thus be obtained at all stages during the process of manufacture.

In the Figure 2 embodiment the underside of the actual workpiece thus constitutes the registration surface previously provided by the second workpiece 30 located on the underside 18 of the table 10.

It is to be understood that the marks which are to be used by the beam 32 in its reading mode, may be

Inscribed either inside or outside the apparatus by using other means such as mechanical scribing or exposure of marks using light optical instruments.

In another embodiment not shown, the underside 70 of the table 10 is scribed or otherwise provided with registration marks which can be read by the beam 32 in its reading mode. As with the Figure 2 embodiment, this avoids the need for a second workpiece but does not possess the advantage of the Figure 2 embodiment where the registration marks are actually carried by the material being processed.

The great advantage of the invention is that the registration marks do not interfere with the surface which is to be scribed by the inscribing beam 20 and therefore the whole area of the wafer or substrate forming the workpiece can be utilised.

In use the registration surface (whether it be the underside of the table, the underside of a second workpiece as in Figure 1, or the underside of the actual workpiece as in Figure 2) is formed with a series of matrix or marks which most conveniently are written thereon by means of beam 32. The marks are processed so that they can subsequently be read by the beam 32 operating in a reading mode. This processing may be by etching or other suitable processing.

With the registration surface in position and the beam 32 operating in a reading mode, the table is moved until the first set of registration marks are found by beam 32. An error signal is generated by circuit 42 which indicates the amount by which the table 10 and/or beam 20 must be moved via devices 12, 14 and 26 and an appropriate shift is provided. The writing sequence using beam 20 can then be initiated and is continued until a unit area of the hitherto unwritten substrate of workpiece 28 has been written upon by the writing beam 20. Once the writing-up of this area has been completed, worktable 10 moves again until a second mark is found by the reading beam 32. Again fine positioning of the beam 20 and table 10 is carried out as required and a further area of the unexposed substrate 28 is written-up until the whole of the surface of the substrate (workpiece) 28 has been written-up. Each area of the substrate so written-up has an accurate reference to the registration surface read by the reading beam 32.

The written-up substrate 28 can now be replaced by a fresh unexposed substrate and the process repeated to cover the new substrate with the pattern or circuit required thereon as defined by the matrix on the registration surface or master substrate 30. It will be seen that the process can be carried out *ad infinitum* so as to create a set of substrates with either identical or differing patterns. A set of substrates produced thereby with the pattern elements of each one accurately positioned relative to those on the other substrates in the set but without any of the marks appearing on the surfaces of the substrates which have been written-up.

In the Figure 2 embodiment, a similar process is carried out except that in the first step prior to the scribing mode of operation, the underside of the substrate 46 is marked by the beam 32 operating in its writing mode. When operating in a subsequent

reading mode, the beam 32 and associated circuits provide the positional information and error correction signals for correcting the position of the beam 20 and/or the worktable 44.

- 5 If one member of the set of exposed substrates has to be replaced at any time after the set has been produced, a new member may be exposed or written-up using the master substrate 30. Any new substrate so produced will fit into the set thus obviating the need to produce a new set every time any one of its members has to be changed.

The Figure 2 embodiment is used when a series of patterns are to be overlaid accurately upon the same substrate. Here the reverse side of the substrate is used in place of the master substrate 30 since the underside of the substrate is now accessible to the beam 32. In this way distortions appearing in the substrate as a result of processing between the first and second exposures can be detected and appropriate corrections made via the circuits 42 and 26 so that errors arising from such distortions can be eliminated.

The invention may be directly applied to the manufacture of electron beam fabricated masks for the production of solid state and semiconductor devices or used in direct fabrication of semiconductor devices onto a silicon wafer and the like. In the latter case both the writing and reading/writing beams are finely focused electron beams. The reading beam operates in the same manner as in the scanning electron microscope and can have resolving power of better than 100AU. Thus it is able to locate the markers on a master substrate to near this degree of accuracy.

- 35 In alternative embodiments not shown in the drawing, the beams may be light beams or ion beams.

The two beams may be prealigned using reference signals generated by grids which reflect electrons.

- 40 Alternatively a target which is partly transparent to electrons may be used to form a scanning transmission electron picture and information derived from the scanning may be used for the purpose of accurately aligning the point of impact on one side of the substrate with the point of impact of the other beam on the other side. Alternatively this information may be used for generating (typically within an associated computer) displacement information which will allow any offset between the two points of impact to be determined and taken into account in subsequent scanning operations.

CLAIMS

- 55 1. Apparatus for scribing a workpiece surface comprising
-a worktable having a working area,
-means for generating a first beam,
-means for directing the first beam towards one face
60 of the working area, for inscribing the surface of a workpiece located in the working area,
-means for generating a second beam,
-means for directing the second beam also towards the working area but onto the opposite face thereof,
65 and

-means for deriving positional information using the second beam.

2. Apparatus as claimed in claim 1 further comprising means responsive to the positional information for controlling the position of the worktable.

3. Apparatus as claimed in claim 1 further comprising means responsive to the positional information for controlling the position of the first beam.

4. Apparatus as claimed in claim 1 wherein the means for generating the first beam and the means for generating the second beam comprise electron columns.

5. Apparatus as claimed in claim 1 wherein a second workpiece is located in the working area below the first workpiece and marks are formed therein which can be read by the second beam and means is provided for operating the second beam in a reading mode to provide the said positional information.

6. Apparatus as claimed in claim 1 wherein the worktable is in the form of a frame and a single workpiece is supported within the frame and the first beam is directed towards one face of the workpiece and the second beam is directed towards the opposite face of the workpiece for reading marks formed thereon to provide the said positional information.

7. Apparatus as claimed in claim 1 wherein the workpiece is situated on one face of the worktable and marks are formed on an opposite face of the worktable and the second beam is operated so as to read the position of the said marks.

8. A method of positioning a first beam directed towards one surface of a workpiece mounted on a worktable and comprising the steps of
-directing a second beam towards the opposite side of the worktable,
-deriving positional information using the second beam, and
-controlling the position of the point of impact of the first beam with the workpiece using the positional information.

9. The method of claim 8 in which the positional information is obtained by scanning marks located on the table, a second workpiece carried on the opposite face of the worktable or on the opposite surface of the one workpiece.

10. The method as claimed in claim 8 wherein the position of the point of impact is controlled by adjusting the position of the table.

11. The method as claimed in claim 8 wherein the position of the point of impact is controlled by adjusting the position of the first beam.

12. A method of inscribing on a workpiece comprising the steps of
-placing the workpiece on a worktable accessible to two writing beams respectively directed to opposite sides of the table,
-using one of the beams to carry out the required inscribing operations on one surface of the workpiece, and
-using the second beam to provide positional information to move the table and/or the first beam in accordance with registration marks read by the second beam and provided on any of the table, the

surface of a second workpiece carried on the table and the opposite surface of the first mentioned workpiece.

13. Apparatus for inscribing workpieces using a first beam in which a second beam generates positional information for correcting errors due to distortion and the like constructed arranged and adapted to operate substantially as herein described with reference to and as illustrated in Figure 1 or Figure 2 of the accompanying drawings.

14. A method of positioning a first beam directed towards one surface of a workpiece mounted on a worktable substantially as herein described with reference to and as illustrated in Figures 1 and 2 of the accompanying drawing.

15. A method of inscribing the surface of a workpiece located on a worktable accessible to two writing beams respectively directed to opposite sides of the table substantially as herein described with reference to and as illustrated in Figure 1 or Figure 2 of the accompanying drawing.

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